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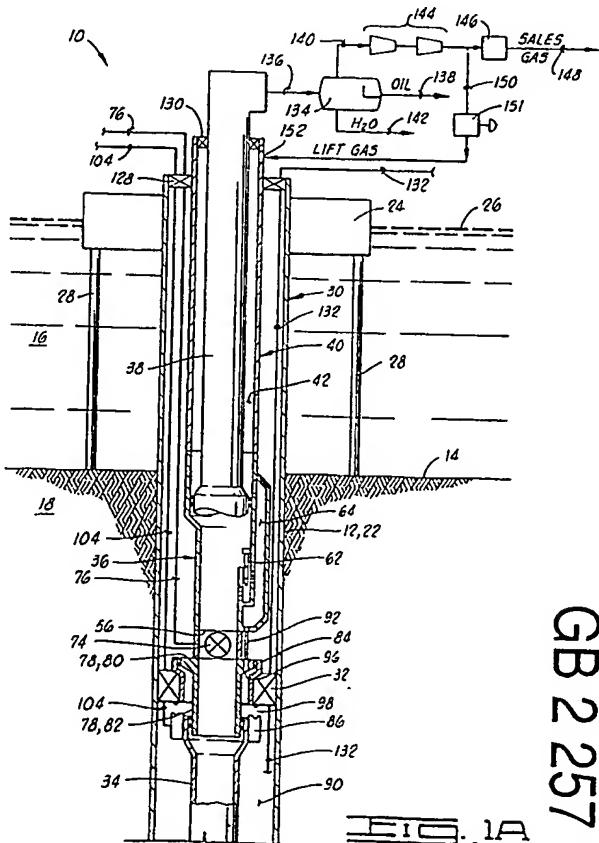
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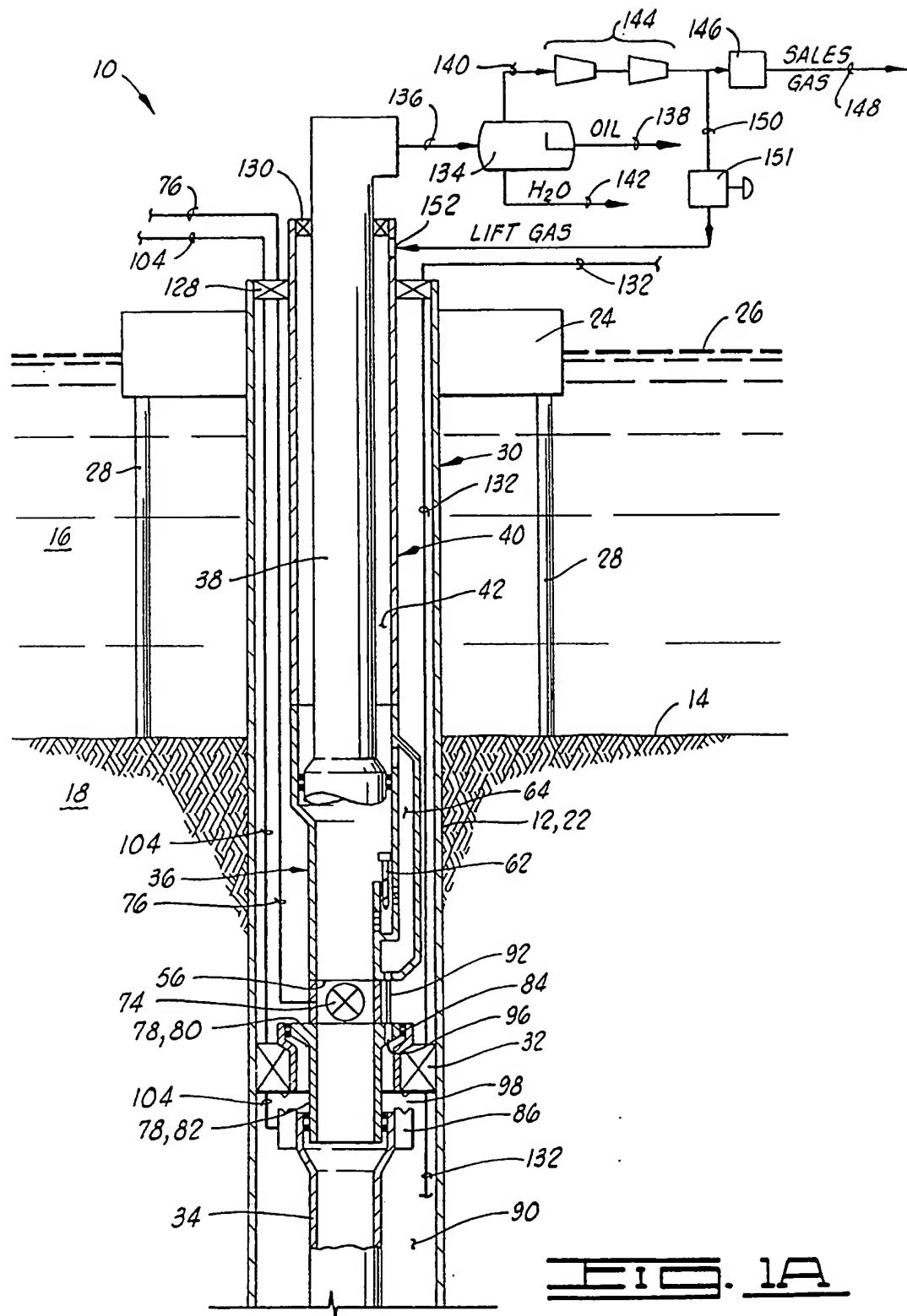
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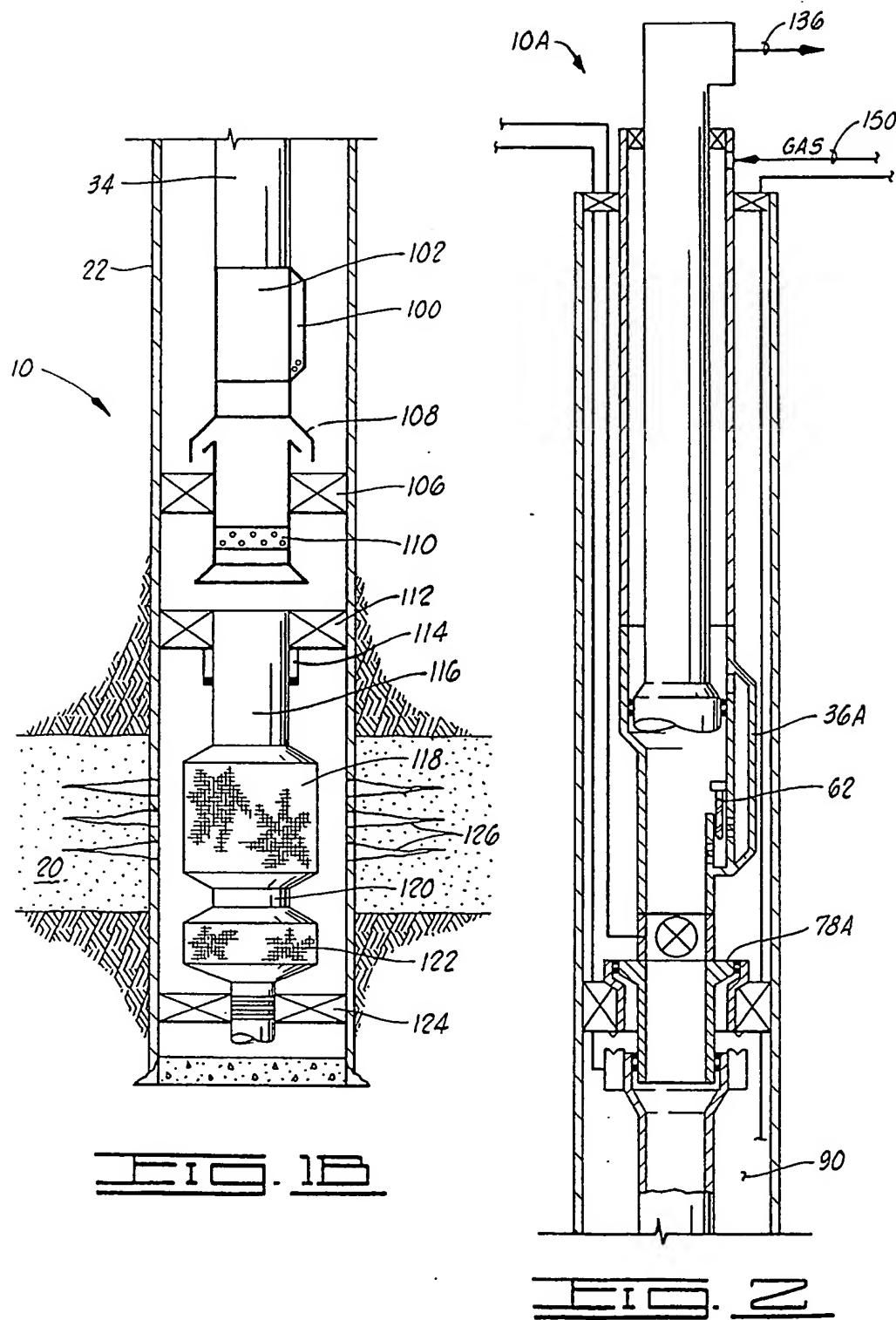
(54) Oil well production system

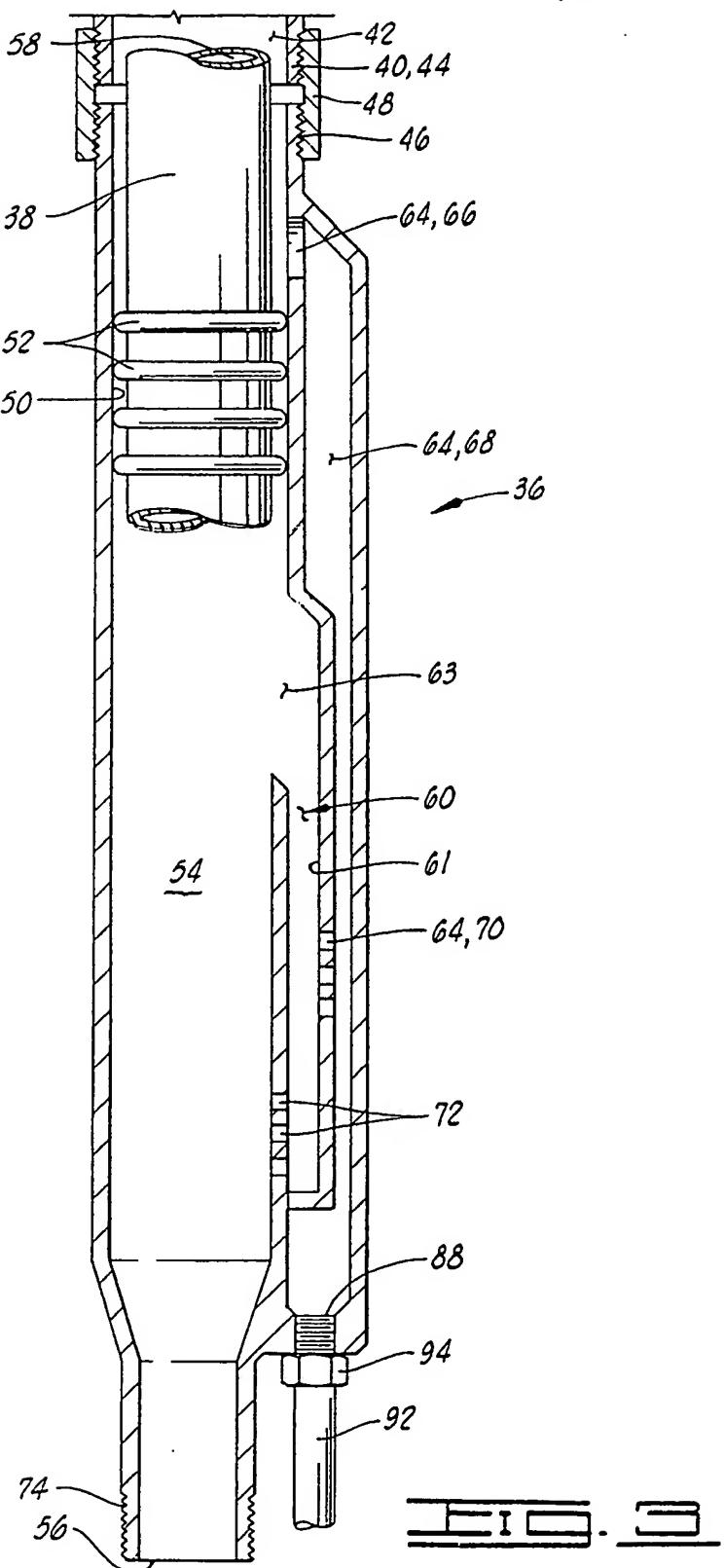
(57) A production system 10 for a subsea well 12 includes a concentric gas lift string 40 and a production tubing string 38 both located within a production riser 30. Lift gas injected down the annulus 42 between the production tubing string 38 and gas tubing string 40 is injected into the production tubing string 38 below the mud line 14 and thus provides gas lift assistance to the produced fluid stream 136. Thus increased produced fluid flow is provided while simultaneously insulating the produced fluid 136 from the surrounding ocean 16 thus maintaining the temperature of the produced fluid 136 which aids separator efficiencies once the produced fluid 136 reaches a surface platform 24 associated therewith. The use of the concentric gas tubing string 40 avoids pressurizing of the production riser 30. A gas lift mandrel 36, and associated apparatus 86, 92 are provided at the subsurface tubing hanger 32 to permit gas to be selectively directed down to a lower gas lift valve located deeper within the well.





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OIL WELL PRODUCTION SYSTEM

5 The present invention relates generally to the production of oil from wells drilled utilizing subsea well-head equipment, and more particularly, but not by way of limitation, to production from wells which utilize gas lift assistance to aid in the production of the oil.

10 A typical production system for a well drilled utilizing subsea wellhead equipment includes a production riser extending upward from the ocean floor to a surface platform. A production tubing string is contained within the production riser and carries a production stream from the well up to the surface platform. An annulus between the 15 production riser and the production tubing is typically filled with liquid. The production stream typically leaves the subsea wellhead at the ocean floor at an elevated temperature. As the fluid flows upward through the production tubing and production riser, a substantial amount 20 of heat is lost to the surrounding body of water which may be at near freezing temperatures. Thus, the production stream will reach the production platform at a temperature much less than the temperature it had when it left the subsea wellhead. The reduced temperature of the production 25 stream when it reaches the surface platform can adversely affect the performance of the platform's separation system thus requiring substantially more separation treatment to meet acceptable oil quality standards.

The prior art also includes production systems

5 providing for injection of gas into the production stream to aid in lifting the production stream to the surface. This technique is generally referred to as a gas lift system. Conventional gas lift systems on offshore wells have a production tubing string located within a production riser. The gas for the gas lift system flows downward through the annulus between the production tubing string and the production riser to one or more gas lift valves which inject it into the rising production stream. An example of such an 10 offshore gas lift system is shown in U. S. Patent No. 4,125,162 to Groves, Sr., et al. A disadvantage of a system like that of Groves, Sr., et al., is that it results in a pressurized production riser.

15 Viewed from one aspect the present invention provides an offshore oil production system for a well extending from the ocean floor downward into the earth and intersecting a subterranean hydrocarbon producing formation. The well is defined by a well casing set in place within the earth.

20 A production platform is located at the surface of the body of water above the well, and a production riser extends from the well at the ocean floor up through the body of water to the production platform.

25 The well includes a subsea wellhead which has a subsurface tubing hanger, preferably located near the mud line or floor of the body of water. A lower production tubing string is hung from the subsurface tubing hanger and extends downward to the producing formation. An upper production tubing string extends upward from the subsea wellhead through the 30 production riser to the production platform.

A gas tubing string is concentrically disposed about the upper production tubing string and is located within the production riser, said gas tubing string being filled in use with gas.

Preferably a gas lift mandrel is mounted above the subsurface

tubing hanger and communicates the upper and lower production tubing strings. The gas lift mandrel has its upper end connected to a lower end of the gas tubing string.

5 A gas lift valve is preferably disposed in the gas lift mandrel for injecting gas from the gas tubing string into the production tubing string.

10 The gas lift mandrel preferably has a seal bore defined therein for sealingly receiving the lower end of the upper production tubing string. The gas lift mandrel also preferably has a gas passage means defined therein for communicating the annulus between the upper production tubing string and the gas lift tubing with the gas lift valve.

15 The gas lift mandrel further preferably includes a bypass port by means of which the gas passage can be communicated with a lower annulus between the lower production tubing string and the well casing below the subsurface tubing hanger so that lift gas can be provided to a second gas lift valve located deeper within the well.

20 Viewed from another aspect, the present invention provides a gas lift mandrel for use with a concentric tubing system having a gas lift tubing and an upper production tubing concentrically disposed in said gas lift tubing so that an annulus is defined therebetween, comprising:

25 an upper end with an upper connection means for connecting said mandrel to said gas lift tubing;

a lower end with a lower connection means for connecting said mandrel to a lower production tubing;

30 receiving means, defined within said mandrel, for sealingly receiving said upper production tubing;

35 a production flow passage, defined within said mandrel from said lower end of said mandrel to said receiving means;

a valve pocket means defined in said mandrel for receiving a gas lift valve therein, said valve pocket means being communicated with said production flow passage; and

35 a gas passage means, defined within said mandrel, for communicating said annulus with said valve pocket means to supply gas to said gas lift valve.

Viewed from another aspect, the present invention provides a method of producing oil from a well located below a body of water up through a production riser extending from said well up through said body of water, comprising:

(a) flowing a produced oil stream up through said body of water, said produced oil stream flowing through a production tubing string extending from said well up through said production riser;

(b) flowing an annular gas stream surrounding said produced oil stream down through said body of water, said annular gas stream flowing through a gas tubing string located within said production riser, said gas tubing string having said production tubing string located therein; and

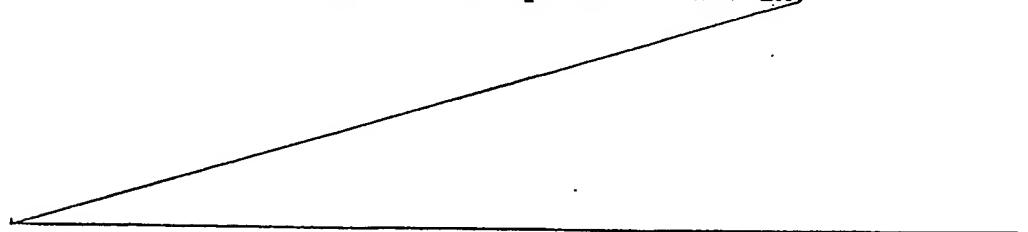
(c) insulating said upwardly flowing produced oil stream from said body of water with said downwardly flowing annular gas stream, thereby reducing heat loss from said produced oil stream as it flows upwardly through said body of water.

Embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings, wherein:

FIGS. 1A-1B comprise a schematic, elevation, sectioned view of the production system of a first embodiment of the present invention and an associated tension leg platform anchored in place over a subsea well.

FIG. 2 is a view similar to FIG. 1 of an alternative embodiment of the invention constructed to only inject lift gas at the first gas lift valve adjacent the ocean floor.

FIG. 3 is a schematic, elevation, sectioned view of the gas lift mandrel used in the system of FIG. 1A,



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Referring now to the drawings, and particularly to FIGS. 1A-1B, an offshore oil production system is shown and generally designated by the numeral 10. The system 10 includes a well 12 extending from a floor 14 of a body of water 16 downward into the earth 18 and intersecting a subterranean hydrocarbon producing formation 20. The well 12 is defined by a casing 22 set in place within the earth by conventional cementing techniques.

The production system 10 further includes a production platform 24 which in the illustrated embodiment is a tension leg platform 24 located at the surface 26 of the body of water 16 and anchored in place over the well 12 by a plurality of tension legs 28 which function in a well known manner.

A production riser 30, which may be an extension of the well casing 22, extends from the well 12 at the ocean floor 14 up through the body of water 16 to the production platform 24.

A subsurface tubing hanger 32 is located in the well 12 very near an elevation to the subsea floor 14. The tubing hanger 32 is associated with a conventional subsea wellhead (not shown) located adjacent floor 14. A lower production tubing string 34 is suspended from the subsurface tubing hanger 32 in a well known manner and extends downward therefrom to the producing formation 20.

A gas lift mandrel 36 is mounted above the subsurface tubing hanger 32. An upper production tubing string 38 extends up from the gas lift mandrel 36 through the production riser 30 to the production platform 24. The gas lift mandrel 36 communicates the upper and lower production tubing strings 38 and 34.

A gas tubing string 40 is concentrically disposed about the upper production tubing string 38 and is located within the production riser 30. A gas annulus 42 is defined

between the upper production tubing string 38 and the gas tubing string 40.

5 The details of construction of the gas lift mandrel 36 and associated connections at its upper and lower ends are best seen in the enlarged view of FIG. 3. A lower end 44 of gas tubing string 40 is connected to a threaded upper end 46 of gas lift mandrel 36 by threaded coupling 48.

10 The mandrel 36 has a seal bore 50, which may also be generally described as a receiving means 50, defined therein for sealingly receiving the lower end of the upper production tubing string 38. The upper production tubing string 38 carries one or more seals 52 which sealingly engage the seal bore 50.

15 A production flow passage 54 is defined within the mandrel 36 extending from a lower end 56 of mandrel 36 up to the seal bore 50 where production flow passage 54 communicates with an interior 58 of upper production tubing string 38 so that produced fluids from the subterranean formation 20 can flow upward through the lower production tubing string 34, then through production flow passage 54 and then up through the upper production tubing string 38.

20 Mandrel 36 includes a valve pocket means 60 defined therein and having a cylindrical bore 61 for receiving a gas lift valve schematically indicated at 62 in FIG. 1A. The valve pocket means 60 is communicated with the production flow passage 54 by a pocket opening or valve entrance 63. This permits the gas lift valve 62 to be run into the gas lift pocket 60 through the upper production tubing string 38 in a conventional manner. The valve pocket means 60 is of the type commonly referred to as a side pocket, and may have various indexing structures associated therewith to aid in installation and removal of valve 62.

25 30 35 The mandrel 36 has a gas passage means 64 defined therein for communicating the annulus 42 between the upper production tubing string 38 and gas tubing string 40 with

the valve pocket means 60 to supply gas to the gas lift valve 62. The gas passage means 64 includes a port 66 communicating with the annulus 42 above the seals 52. Gas passage means 64 further includes a longitudinal passage portion 68 extending downward from port 66. Gas passage means 64 further includes one or more supply ports 70 which supply the gas directly to the gas lift valve 62 in the valve pocket means 60.

One or more injection ports 72 communicate with the production flow passage, so that the gas lift valve 62 can selectively direct injection gas from gas passage means 64 through the injection port 72 into the production flow passage 54.

The lower end 56 of mandrel 36 has an external thread 74. As best seen in FIG. 1A, the lower end 56 of mandrel 36 is connected to a tubing retrievable surface controlled subsurface safety valve 74 which blocks the production tubing string 38,34 adjacent the subsurface tubing hanger 32. A control line 76 extends from the surface down to safety valve 74 to control the same.

The safety valve 74 is connected to a mounting adapter 78 which has an enlarged diameter upper portion 80 and a smaller diameter lower portion 82.

The threaded connector 74 at the lower end 56 of mandrel 36 can generally be described as a lower connection means 74 for connecting the mandrel 36 to the lower production tubing string 34 via the other associated apparatus such as safety valve 74 and adapter 78 located therebetween.

The subsurface tubing hanger 32 has a seal bore member 84 connected to the upper end thereof. The enlarged diameter upper portion 80 of mounting adapter 78 is sealingly received within seal bore member 64.

The subsurface tubing hanger 32 has a surface controlled annulus safety valve 86 associated therewith and

connected thereto. The annulus safety valve 86 is schematically illustrated in FIG. 1A, and has the smaller diameter lower portion 82 of mounting adapter 78 sealingly received therein. A control line 104 extends from the 5 surface down to annulus safety valve 86.

The gas lift mandrel 36 has a bypass port 88 defined therein for allowing gas to flow from the gas passage means 64 into a lower annulus 90 between the lower production tubing string 34 and the well casing 22.

10 A length of tubing 92 is connected to port 88 by tubing connector 94 at its upper end. The lower end of tubing 92 is connected to a lower gas port 96 in mounting adapter 78 which provides communication via annulus safety valve port 98 of annulus safety valve 86 to the lower annulus 90.

15 Thus, when the annulus safety valve 86 is in an open position as illustrated in FIG. 1A with the annulus safety port 98 open, and a dummy valve in place of valve 62, the gas flowing downward through gas annulus 42 and gas passage means 64 can flow down through tubing 92, lower gas port 96, and through annulus safety valve port 98, then down through 20 lower annulus 90 to a lower gas lift valve means 100 schematically illustrated in FIG. 1B as being located in a lower gas lift mandrel 102. The gas will be injected into the lower production tubing string 34 at the elevation of 25 lower valve 100 to assist in lifting the produced fluids up through the lower production tubing string 34.

30 The bypass port 88 can generally be described as a bypass port means 88 defined in mandrel 36 for communicating the gas annulus 42 with the lower gas lift valve 100 located below mandrel 36.

35 One advantage of the system 10 is that it permits the use of corrosion resistant alloy production tubing, which is desirable in many wells where the produced oil stream contains contaminants which would corrode conventional steel tubing. The system 10 allows the use of tubing which is

readily available in such alloy compositions.

5 The lower portions of production system 10 seen in FIG. 1B include a conventional production packer 106 located above producing formation 20. An anchor assembly 108 is associated therewith. A ported tail pipe assembly 110 is located below production packer 106.

10 A gravel pack packer 112 is set within the casing 22 below ported tail pipe assembly 110. A gravel pack extension 114 with sliding sleeve valve is associated therewith. A section of blank pipe 116 is located below the gravel pack extension 114. A main gravel pack screen 118 is located below blank pipe 116. An O-ring seal sub 120 is connected below main gravel pack screen 118. A lower telltale screen 122 and a sump packer 124 complete the 15 system.

20 A plurality of perforations such as 126 extend through the well casing 22 into the producing formation 20 to communicate the producing formation 20 through the main gravel pack screen 118 with the lower production tubing string 34 located thereabove, so that produced fluids such as hydrocarbons and some water produced from the formation 20 flow through the perforations 126, then in through the main gravel pack screen 118 up through the various structures associated therewith and then up through the 25 lower production tubing string 34, then subsequently up through the upper production tubing string 38 to the platform 24.

30 At the platform 24, a lower surface tubing hanger 128 suspends the gas tubing string 40 within the riser 30 and provides a seal therebetween. An upper surface tubing hanger 130 similarly suspends the upper production tubing string 38 within the gas tubing string 40 and provides a seal therebetween. Tubing hangers 128 and 130 are associated with a conventional surface wellhead and 35 Christmas tree arrangement (not shown).

5 The control lines 76 and 104 extend downward through the lower surface tubing hanger 128 in a known manner. An additional communication line 132 is provided and is connected to permanently installed downhole pressure and temperature gauges (not shown) which are located at an appropriate position within the well 12.

10 Located on the platform 24 is a separator system 134 which is schematically illustrated. A produced fluid stream 136 from upper production tubing string 38 is directed to the separator system 134 which generally serves to separate the production fluid stream 136 into an oil stream 138 and a gas stream 140. Additionally, there may be a reject water stream 142.

15 The gas stream 140 is generally taken through a plurality of compressors which comprise a gas compression train 144 and then it is cooled in a gas cooler 146 before being directed to a gas sales line 148.

20 In one preferred embodiment of the invention, the gas for gas lift injection is taken off the gas compression train 144 prior to the gas entering the gas cooler 146 as indicated by gas takeoff line 150 which is connected to a main gas supply connection 152 which communicates with the gas annulus 42. Gas supply is regulated to the gas annulus 42 by a pilot valve 151.

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Preferred methods of producing oil from the well 12 utilizing the system 10 can generally be described as follows.

30 One of the primary purposes of the system 10 is to minimize heat loss from the produced oil stream flowing upward through production tubing string 38 and through the body of water 16 which will typically be much colder than the produced oil stream. This can be accomplished with the system 10 by insulating the upwardly flowing produced oil stream by means of the downwardly flowing annular gas stream

contained in gas annulus 42 which surrounds the upper production tubing string 38.

5 Thus, the method includes a step of flowing the produced oil stream up through the upper production tubing string 38 and thus up through the body of water 16 from the well 12 to the platform 24.

10 The method includes the step of simultaneously flowing an annular gas stream surrounding the produced oil stream down through the gas annulus 42 and thus down through the body of water 16.

15 The method further includes the step of insulating the upwardly flowing produced oil stream from the body of water 16 with the downwardly flowing annular gas stream. This reduces heat loss from the produced oil stream as it flows upwardly through the body of water 16, as compared to those prior art systems which merely have a production tubing string extending through a production riser with the annulus therebetween filled with a liquid which very readily 20 conducts heat away from the oil stream to the surrounding body of water 16.

25 Thus a preferred method of producing oil with the system 10 can be described as including a step of avoiding pressurizing the production riser 30 with the gas stream by containing the gas stream in the gas tubing string 40.

30 There are also significant advantages as compared to those prior art systems like that of U. S. Patent No. 4,125,162 to Grove, Sr., et al., wherein gas lift gas is conveyed downwardly through an annulus between the production tubing string and the gas riser, because in the 35 Grove, Sr., et al. type of system, the production riser itself is pressurized which has disadvantages.

35 It will be appreciated that in its broadest aspects, the present invention need not include the injection of the gas into the produced oil stream in sufficient quantities to provide gas lift assistance to the produced oil stream.

However in a preferred embodiment, the gas lift mandrel 36 and associated gas lift valve 62 are provided so that the method can include a step of injecting at least a portion of the gas from the annular gas stream into the upwardly flowing produced oil stream and thereby providing gas lift assistance to the produced oil stream.

The gas is preferably injected into the upwardly flowing produced oil stream at a location below the mud line 14 of the body of water 16, as indicated in FIG. 1A by the 10 location of gas lift valve 62 below the mud line 14.

Thus, the annular gas stream in gas annulus 42 can be described as surrounding and insulating the produced oil stream across the entire depth of the body of water 16 from the mud line 14 up to the surface 26.

15 Further, a method of utilizing the system 10 can include a step of selectively bypassing at least a portion of the gas stream past the first gas lift valve 62 down into the well 12 through the lower annulus 90 to a second gas lift valve 100 located substantially deeper within the well. 20 Gas is again injected into the upwardly flowing produced oil stream at the second gas lift valve 110 thereby again providing gas lift assistance to the produced oil stream.

25 The flow of gas down to this second gas lift valve 100 is permitted by opening the annulus safety valve 86. It is noted that the upper gas lift valve 62 may if desired be replaced with a dummy valve to prevent any gas injection at the upper location. Also, the upper and lower gas lift valves 62 and 100 may be constructed to operate at differing 30 gas supply pressures so that the lower gas lift valve 100 can operate without operating the upper gas lift valve 62 if desired.

35 The gas provided to main gas supply connection 152 may be at ambient temperature if the insulation effect provided thereby is sufficient to maintain the temperature of the produced oil stream at the desired level when it reaches

platform 24. If further heating of the produced oil stream is required, the lift gas can be taken off the gas compression train 144 as previously described. That gas from the gas compression train 144 may for example be at 5 temperatures as high as 300° F., and thus can be described as being heated to substantially above ambient atmospheric temperature.

The efficiency of the separator system 134 is significantly dependent upon the temperature of the produced 10 oil stream which is provided thereto, since the heat enhances the separation process. If it were not for the insulating, and in some cases further heating, effect of the gas flowing downward through gas annulus 42, the temperature 15 of the produced oil stream would be significantly lower than it is with the use of the system 10, and thus the separator system 134 located on the platform 24 would be required to be substantially larger than it needs to be with this system 10 according to a preferred embodiment of the present invention.

The space and weight capacity on an offshore platform, 20 and particularly on a tension leg platform are at a premium and have a high cost associated therewith. Thus, the reduction in size of the necessary separator system 134 and elimination of certain ancillary equipment, i.e., coalescers, heaters, etc., by means of maintaining and/or 25 increasing the heat of the produced oil stream provided thereto provides significant economic advantages.

It may, for example, be desired to maintain the temperature of the produced oil stream at greater than or 30 equal to 140° F. in order to achieve desired efficiencies (e.g., 0.5 Vol. % BS&W) in the separator system 134. The produced oil stream may enter the upper production tubing string 38 adjacent mud line 14 at a temperature of 165° F. and in North Sea conditions having a water temperature of 35 approximately 39° F. and a depth of approximately 1150 ft. at a flow rate of approximately 15,000 BPD, a temperature of

the produced fluid stream at the platform 12 of approximately 104° F. could be expected in the absence of the insulating gas annulus 42, with a system wherein the annulus between production string 38 and production riser 30 were filled with a conventional liquid. The presence of the insulating gas in gas annulus 42 can reduce heat losses such that the produced oil stream has a temperature of no less than the required 140° F. necessary for efficient operation of separator system 134.

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In FIG. 2 a slightly modified system 10A is illustrated in a manner similar to FIG. 1A, except that surrounding structures such as the platform 24 have been eliminated for ease of illustration. The system 10A is similar to the system 10, except that the gas lift mandrel has been modified and is now indicated by the numeral 36A. The gas lift mandrel 36A has the port 88 closed by a plug. The tubing 92 has been eliminated and no communication is provided between gas passage means 64 and the lower annulus 90. The adapter 78A has also been modified to eliminate or plug the lower gas port 96.

Thus with the system 10A, gas is injected only at the location of upper gas lift valve 62. The lower components of system 10A will be substantially as shown in FIG. 1B for the system 10. Similarly, the upper portion of the system 10A including separator system 134, etc., will be similar to that shown in FIG. 1A, but those structures associated with separator system 134 are not shown, again for ease of illustration.

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Thus it is seen that at least preferred apparatus and methods of the present invention readily achieve the ends and advantages mentioned as well as those inherent therein. While certain preferred embodiments of the invention have been illustrated for purposes of the present disclosure, numerous changes may

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be made by those skilled in the art which changes are encompassed within the scope and spirit of the present invention.

CLAIMS:

1. A gas lift mandrel for use with a concentric tubing system having a gas lift tubing and an upper production tubing concentrically disposed in said gas lift tubing so that an annulus is defined therebetween, comprising:

5 an upper end with an upper connection means for connecting said mandrel to said gas lift tubing;

10 a lower end with a lower connection means for connecting said mandrel to a lower production tubing;

receiving means, defined within said mandrel, for sealingly receiving said upper production tubing;

15 a production flow passage, defined within said mandrel from said lower end of said mandrel to said receiving means;

a valve pocket means defined in said mandrel for receiving a gas lift valve therein, said valve pocket means being communicated with said production flow passage; and

20 a gas passage means, defined within said mandrel, for communicating said annulus with said valve pocket means to supply gas to said gas lift valve.

2. The gas lift mandrel of claim 1, wherein:

25 said valve pocket means is a side pocket having a valve entrance communicated with said production flow passage.

3. The gas lift mandrel of claim 1 or 2, wherein:

30 said valve pocket means includes a cylindrical pocket bore for receiving said gas lift valve, a supply port communicating said pocket bore with said gas passage means, and an injection port communicating said pocket bore with said production flow passage.

4. The gas lift mandrel of any preceding claim, further comprising:

5 bypass port means, defined in said mandrel, for communicating said annulus with a lower gas lift valve located below said mandrel.

5. The gas lift mandrel of any preceding claim, wherein:
said receiving means is a seal bore.

10 6. A method of producing oil from a well located below a body of water up through a production riser extending from said well up through said body of water, comprising:

15 (a) flowing a produced oil stream up through said body of water, said produced oil stream flowing through a production tubing string extending from said well up through said production riser;

20 (b) flowing an annular gas stream surrounding said produced oil stream down through said body of water, said annular gas stream flowing through a gas tubing string located within said production riser, said gas tubing string having said production tubing string located therein; and

25 (c) insulating said upwardly flowing produced oil stream from said body of water with said downwardly flowing annular gas stream, thereby reducing heat loss from said produced oil stream as it flows upwardly through said body of water.

7. The method of claim 6, further comprising:

30 (d) injecting at least a portion of the gas from said gas stream into said upwardly flowing produced oil stream and thereby providing gas lift assistance to said produced oil stream; and

 (e) avoiding pressurizing said production riser with said gas stream by containing said gas stream in said

gas tubing string.

8. The method of claim 7, wherein:

5 said step (d) is further characterized as injecting said gas into said upwardly flowing produced oil stream at a location below a mud line of said body of water.

9. The method of claim 7 or 8, wherein:

10 said step (d) is further characterized as injecting said gas into said produced oil stream at a first location adjacent a mud line of said body of water; and

wherein said method further comprises steps of:

(f) selectively bypassing at least a portion of said gas stream past said first location down into said well to a second location substantially deeper than said first location; and

15 (g) injecting gas into said upwardly flowing produced oil stream at said second location and thereby providing gas lift assistance to said produced oil stream.

10. The method of claim 9, wherein:

20 said step (f) is further characterized as opening an annulus safety valve to let said gas stream pass downward between said production tubing string and a casing string of said well.

11. The method of any of claims 6 to 10, wherein:

25 said steps (b) and (c) are further characterized in that said annular gas stream surrounds and insulates said produced oil stream across the entire depth of said body of water from a mud line of said body of water to the surface of said body of water.

12. The method of any of claims 6 to 11, further comprising:

30 prior to step (b) heating said gas to

substantially above ambient atmospheric temperature.

13. The method of claim 12, wherein:

5 said gas is taken off a gas compression train of a production platform prior to the gas entering a gas cooler of said gas compression train.

14. The method of any of claims 6 to 13, wherein:

10 said step (a) is further characterized as flowing said produced oil stream up through said production tubing string to a tension leg platform floating on the surface of said body of water; and

15 said steps (b) and (c) are further characterized as enhancing an efficiency of separation of said produced oil stream on said tension leg platform due to the increased temperature of said produced oil stream when it reaches said tension leg platform, thereby allowing separated oil quality standards to be met with a reduced amount of separator equipment located on said tension leg platform as compared to what would be required in the absence of said steps (b) and (c).

20 15. An offshore oil production system, comprising:

25 a well extending from a floor of a body of water downward into the earth and intersecting a subterranean hydrocarbon producing formation, said well being defined by a well casing set in place within the earth;

25 a production platform located at the surface of said body of water;

30 a production riser extending from said well at said floor up through said body of water to said production platform;

30 a subsurface tubing hanger located in said well;

30 a lower production tubing string extending downward from said subsurface tubing hanger to said

producing formation;

an upper production tubing string extending upward through said production riser to said production platform; and

5 a gas tubing string concentrically disposed about said upper production tubing string and located within said production riser, said gas tubing being filled with gas.

16. The system of claim 15, further comprising:

10 a gas lift mandrel connected to said subsurface tubing hanger and communicating said upper and lower production tubing strings, said gas lift mandrel being connected to a lower end of said gas tubing string; and

15 a gas lift valve means disposed in said gas lift mandrel for injecting gas from said gas tubing string into said upper production tubing string.

17. The system of claim 16, wherein:

20 said gas lift mandrel includes a side pocket communicated with said upper production tubing string, said gas lift valve being retrievable and installable by running through said upper production tubing string.

18. The system of claim 16 or 17, wherein:

said gas lift mandrel includes a seal bore in which a lower end of said upper production tubing string is sealingly received.

19. The system of any of claims 15 to 18, further comprising:

a surface controlled subsurface safety valve means for blocking flow through said upper and lower production tubing strings adjacent said subsurface tubing hanger.

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20. The system of any of claims 15 to 19, further comprising:

a bypass port defined in said gas lift mandrel for allowing gas to flow into a lower annulus between said lower production tubing string and said well casing; and

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a lower gas lift valve means, disposed in said lower production tubing string, for injecting gas from said lower annulus into said lower production tubing string.

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21. The system of claim 20, further comprising:

a surface controlled annulus safety valve means for controlling communication between said bypass port and said lower annulus.

22. A gas lift mandrel substantially as hereinbefore described with reference to Figures 1A, 1B and 3, or Figure 2 of the accompanying drawings.

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23. A method of producing oil from a well located below a body of water substantially as hereinbefore described with reference to Figures 1A, 1B and 3, or Figure 2 of the accompanying drawings.

25

24. An offshore oil production system substantially as hereinbefore described with reference to Figures 1A, 1B and 3, or Figure 2 of the accompanying drawings.

Relevant Technical fields

(i) UK CI (Edition K) E1F (FKB)

(ii) Int CI (Edition 5) E21B

Search Examiner

D J HARRISON

Databases (see over)

(i) UK Patent Office

(ii)

Date of Search

25 SEPTEMBER 1992

Documents considered relevant following a search in respect of claims

1-5

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
	NONE	

Category	Identity of document and relevant passages	Relevance to claim(s)

Categories of documents

X: Document indicating lack of novelty or of inventive step.

Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

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